

IBM Systems Reference Library

IBM 1301, Models 1 and 2, Disk Storage and IBM 1302, Models 1 and 2, Disk Storage with IBM 7090, 7094, and 7094 II Data Processing Systems

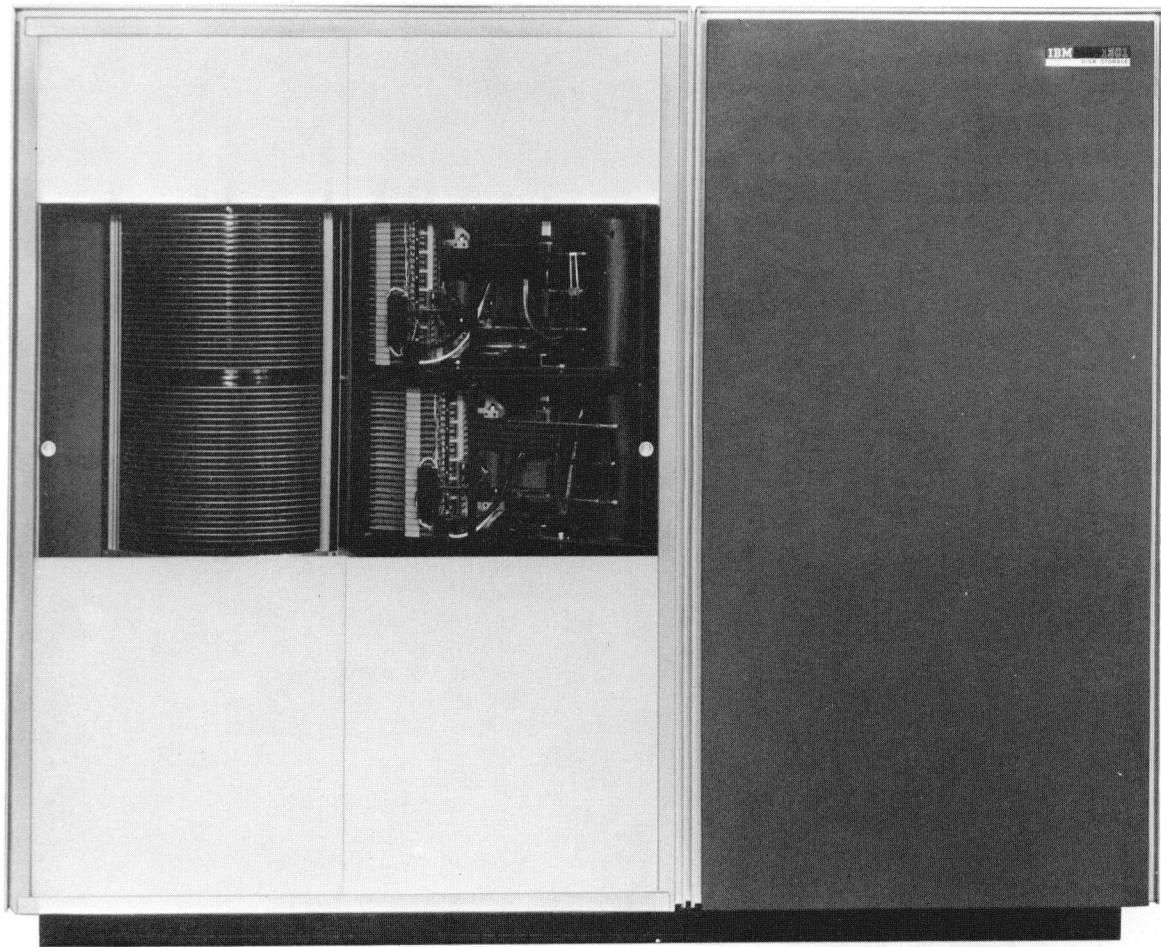
This manual provides information concerning IBM Disk Storage — the IBM 1301, Models 1 and 2, and the IBM 1302, Models 1 and 2 — as used with the IBM 7090, 7094, and 7094 II Data Processing Systems. Use of this manual assumes a basic knowledge of these systems.

This publication, Form A22-6785, obsoletes the *General Information Manual IBM 1301 Disk Storage with IBM 7000 Series Data Processing Systems*, Form D22-6576-3, and *IBM 1301 Disk Storage with 7090 and 7094 Systems*, Form A22-6745.

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IBM 1301 Disk Storage

IBM 1301 and 1302 Disk Storage with IBM 7090, 7094, and 7094 II Data Processing Systems

Advanced principles of disk storage are made available for use with IBM 7090, 7094, and 7094 II Data Processing Systems by the IBM 1301, Models 1 and 2, and the IBM 1302, Models 1 and 2, Disk Storage units. These units are similar in appearance and differ primarily in data capacity and data transmission rate. The table at the right shows some comparisons of each disk storage unit as used in the 7090, 7094, and 7094 II systems.

Applications of Disk Storage

Disk storage provides IBM 7090, 7094, and 7094 II Data Processing Systems with the unique ability to either sequentially or randomly record and retrieve externally stored data. It permits the immediate access to specific areas of information without the need to sequentially examine all data recorded in the same file. The fast speed of access to data storage locations provided by random access data processing enables the user to maintain up-to-the-minute files and to make frequent direct reference to and retrieval of the stored data, regardless of the time of record insertion or the physical location of the disk-stored data.

The extensive data storage capacity, swift access to recorded data, high data transmission rates to and from the computer, and broad flexibility of file maintenance and organization provided by disk storage devices introduce new and advanced data processing methods and foster simplification of procedures.

For example, used in conjunction with a magnetic tape system, random access storage can:

Reduce the Number of Tape Reels and Setup Time in a given processing operation.

Provide On-Line Storage Facilities for both programs and data, reducing the number of runs and set-ups required.

Facilitate Data Sequencing Requirements because larger tape files can be loaded into disk storage and referred to randomly; this results in substantial reductions in the need for extensive tape sorting runs.

Disk storage expands a system's "working storage" capability, capacity, and accessibility. Each disk cylinder can be used as the operating substitute of a reel of tape. With as many as 500 cylinders available per module, enormous data file availability and capacity are provided, along with swift data access times, and without any tape reel mounting, rewinding, backspacing, or sequential searching activities.

	<u>1301-1</u>	<u>1301-2</u>	<u>1302-1</u>	<u>1302-2</u>
Number of Disk Modules per Unit	1	2	1	2
Number of Cylinders per Unit	250	500	500	1,000
Number of Addressable Data Tracks per Unit	10,000	20,000	20,000	40,000
Number of Access Mechanisms per Module	1	1	2	2
Data Track Record Capacity				
6-bit characters*	2,796	2,796	5,844	5,844
8-bit characters**	2,160	2,160	4,524	4,524
36-bit words***	466	466	974	974
Data Capacity per Unit				
6-bit characters	27,960,000	55,920,000	116,880,000	233,760,000
8-bit characters**	21,600,000	43,200,000	90,480,000	180,960,000
36-bit words***	4,660,000	9,320,000	19,480,000	38,960,000
Maximum Capacity per Cylinder				
6-bit characters	111,840	111,840	233,760	233,760
8-bit characters**	86,400	86,400	180,960	180,960
36-bit words***	18,640	18,640	38,960	38,960
Character Transfer Rate (per Second)				
6-bit characters	90,100	90,100	184,000	184,000
8-bit characters**	70,100	70,100	143,000	143,000
Access Mechanism Motion Times (in Milliseconds)				
50/120/180 50/120/180 50/120/180 50/120/180				
Average Rotational Delay (in Milliseconds)				
17 17 17 17				
Scan Time per Cylinder (Seconds)				
1.33 1.33 1.33 1.33				
Data Channel Weights				
7090 12.4 12.4 34.6 34.6				
7094 9.6 9.6 21.2 21.2				
7094 II 9.6 9.6 21.2 21.2				

*Adjusted for 6-character, 36-bit fixed length words used in IBM 7090, 7094 and 7094 II operations.

**8-bit mode is applicable in the 7090, 7094, and 7094 II systems in shared-file operations with systems using 8-bit mode.

***Based on HA₂ of six characters.

IBM 1301 and 1302 Disk Storage

High data capacity, swift access, flexibility of data organization, and processing modes available with disk storage are provided by the design of the IBM 1301 and 1302 Disk Storage. The recording medium of disk storage consists of thin, magnetically coated metal disks. Data and control information are recorded as magnetized spots on concentric tracks on the surfaces of the disks (Figure 1). Each data recording surface of the 1301, Models 1 and 2 contains 250 data tracks; each surface of the 1302, Models 1 and 2, contains 500 data tracks.

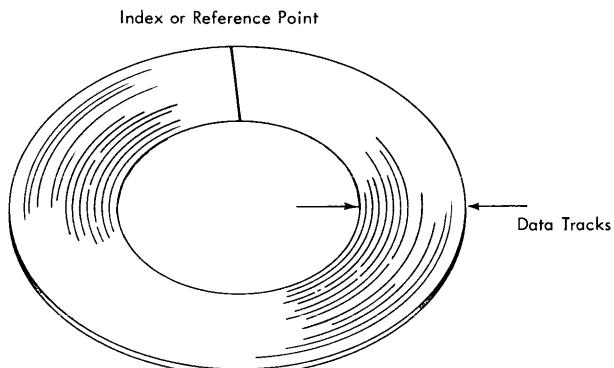


Figure 1. Magnetically Coated Disk

In the 1301 and 1302, the magnetic disks are mounted on a vertical shaft. The shaft rotates, spinning the disks at about 1,790 revolutions per minute. An access mechanism positions read-write heads (Figure 2) close to the spinning disks to make the tracks accessible for reading or writing. The 1301-1 and 1301-2 use one access mechanism; the 1302-1 and 1302-2 use two access mechanisms.

A stack of 25 magnetic disks (50 disk surfaces) with the associated access mechanism(s) make up a disk storage module. The 1301-1 and the 1302-1 are single module units; the 1301-2 and the 1302-2 are double module units.

Of the 25 disks in a stack, 20 disks (40 disk surfaces) are used to store data. The remaining 5 disks (10 surfaces) are used for machine control and as alternate surfaces as follows: six surfaces are used as alternate surfaces, one surface is used to provide format tracks, two surfaces (the top disk surface and the bottom disk surface) are not used for data processing operations. One surface opposite the format surface is a spare surface and is not addressable.

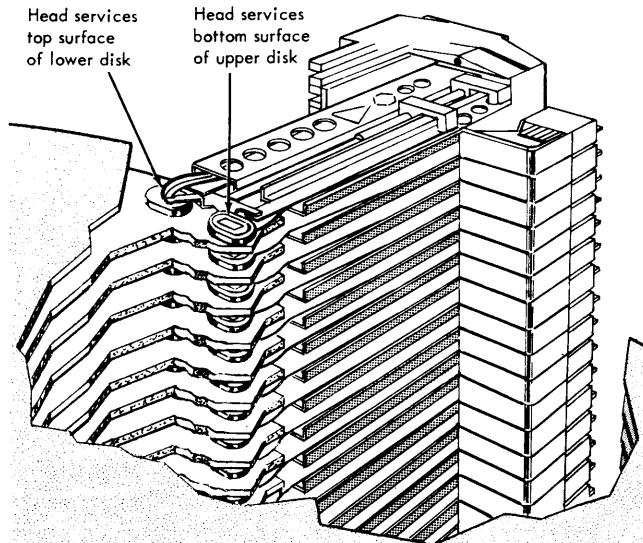


Figure 2. Head Arrangement

The six alternate surfaces are provided so that each data bit can be stored in a magnetically perfect medium. If a disk is encountered, the entire track in which the defect occurs is disabled and an alternate surface is specified. This alternate surface is given the address of the disabled track.

The format disk surface and its usage in providing flexibility of record length and format are discussed later.

Access Mechanisms

Information is written on or read from the disk surfaces by magnetic read-write heads mounted on a comb-like access mechanism. The access mechanism has 40 data read-write heads, one format head, and from two to six alternate surface heads. One additional head is used for maintenance purposes.

The access mechanism is hydraulically driven to simultaneously move all heads horizontally to any area of the 250 data cylinders of the access group. After the horizontal movement is completed to the correct track location, one of the data head elements, which consists of both read and write heads, is electronically selected to perform the reading or writing operation on a particular track in the cylinder. The read-write head associated with the format track is moved laterally in unison with the data read-write heads.

Disk Cylinders

In each module of disk storage, corresponding disk tracks of each surface are physically located one above the other. These tracks form a *cylinder* of 40 data tracks, permitting 40 tracks of information to be immediately available. With this vertical alignment of tracks, the mechanical accessing of data by the access mechanism is eliminated, with only electronic switching from one read-write head to another being required. The use of cylinders of data in 1301, Models 1 and 2, and 1302, Models 1 and 2, operations differs from previous types of disk operations as shown in Figure 3.

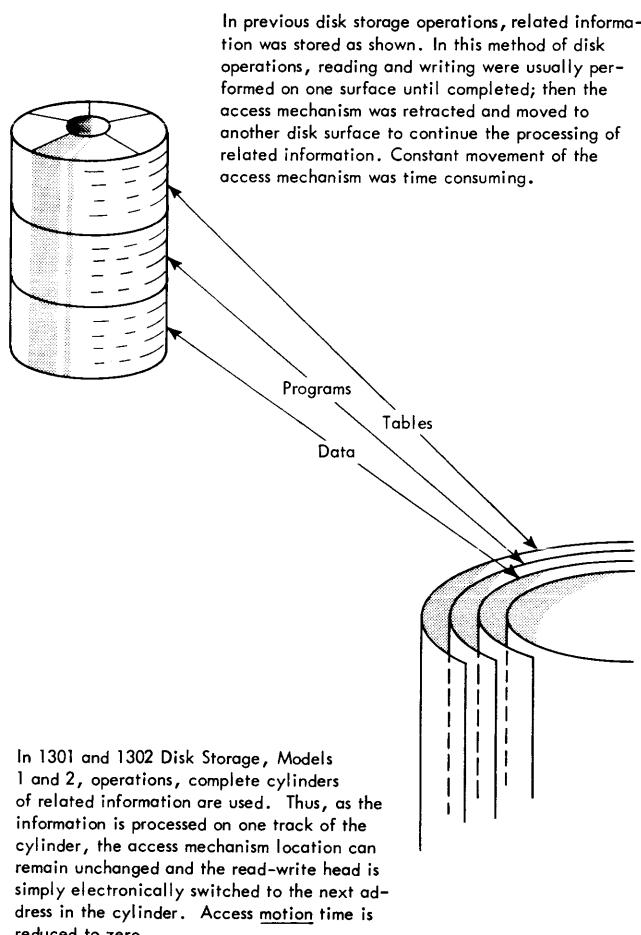


Figure 3. Disk Storage Cylinder Operation

Data Track, Cylinder and Access Numbering

The data tracks of the cylinders are numbered sequentially from bottom to top and from the outermost cylinder to the innermost cylinder of each access

group. For example, the 1301-1 and 1301-2 Disk Storage, with 250 cylinders in a single access group, contain track numbers 0000 to 9999. The data tracks are numbered sequentially, beginning at the outermost cylinder of the lowest data disk surface (track number 0000) and continuing up through this outermost cylinder to track 0039. Numbering continues with the lowest data track of the adjacent inner cylinder as track number 0040 and numbering up the cylinder to track number 0079. Continuing through each of the cylinders of the single access group in like manner, the last track number, 9999, is the top track of the innermost cylinder.

In the 1302, which contains two access groups of 250 cylinders per group, the same track and cylinder numbering system is used. The second access group of tracks and cylinders is also numbered from 0000 to 9999. By the combination of access mechanism number and track number, each of the thousands of tracks on a module can be individually addressed.

The single access mechanism on the 1301-1 and 1301-2 is always addressed as Access 0. The two access mechanisms of the 1302-1 and 1302-2 are addressed as Access 0 for the outer 250 cylinders and Access 1 for the inner 250 cylinders.

The two access mechanisms on the 1302 operate independently, and both may be in motion simultaneously. Each mechanism is restricted to motion within its own zone of operation; accordingly, one access mechanism cannot read a track written by the other access mechanism.

The cylinder arrangement of tracks permits the optional feature *cylinder mode of operation* to read or write a cylinder (or part of a cylinder) of tracks with a single file control order, thus further reducing processing time beyond the reduction in time due to elimination of access motion time.

Module Numbering

Five 1301-1302 units (Models 1 or 2) may be attached to a 7090, 7094, or 7094 II Data Processing System. If all five were Model 2 units, consisting of two modules each, ten modules would be available. The module number for each disk storage unit is determined by the fixed assignment of cable connectors between the IBM 7631 File Control unit and the attached disk storage unit.

7631 CABLE CONNECTOR

DISK MODULE	
First	0 and 1
Second	2 and 3
Third	4 and 5
Fourth	6 and 7
Fifth	8 and 9

The lower module of a disk storage unit is always the even numbered module; the upper module is always the odd numbered module.

Data Track Addressing

To address one data track of the maximum possible total of 200,000 (five 1302 Model 2's), it is necessary to specify the following:

Module	0-9
Access	0-1
Track Number	0000-9999 (Internal circuitry will select the specific read-write head involved.)

Data Access Times

IBM 1301, Models 1 and 2, and 1302, Models 1 and 2, Disk Storage are designed with three interrelated modes of data access. Two of these modes are mechanical in operation, requiring time for performance. The third is electronic and is generally considered as nonexistent in time performance requirements (zero time).

Figure 4 shows a simplified, single-module disk storage with one comb-like access mechanism. Access to one specific track on a given recording surface is accomplished by the lateral movement of the whole access mechanism from a current track location. The time required for this movement is called access motion time (T_A in Figure 4) and is related to the lateral distance the arm moves. Figure 5 shows the time requirements for access motion time for the IBM 1301, Models 1 and 2, Disk Storage, and Figure 6 shows the access motion time for IBM 1302, Models 1 and 2, Disk Storage.

In addition to access motion time, an additional timing factor known as rotational delay time (T_R in Figure 4) is encountered. Rotational delay time is the time required for the disk to position the desired record at the selected read-write head. Maximum rotational delay time is 34 milliseconds; average rotational delay time is 17 milliseconds.

The selection of the proper read-write head is performed simultaneously with access motion time. The read-write head selection time (T_E in Figure 4) consists solely of electronic switching and is negligible.

Total data access time includes the summation of access motion time and rotational delay time. Average rotational delay time (17 milliseconds) is generally used in this calculation.

Data Track Organization

The basic recording area of the disk storage unit is the data track; however, the entire recording area of a track cannot be used exclusively for data storage.

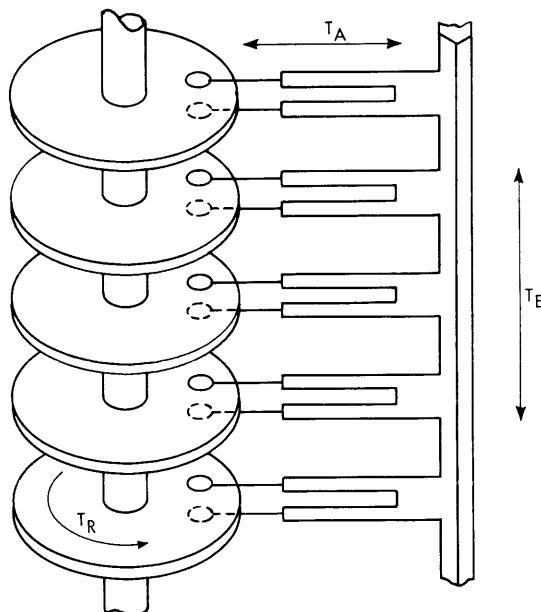


Figure 4. Disk Access Time Requirements

Other information must be recorded on the track before the track is used as a record storage area. On subsequent read or write operations, this information is used to identify the track and each of the record areas used for the storage of data on that track.

A data track and the data to be written or read from a track are identified by a home address 1 (HA1), a home address 2 (HA2), and as many record addresses (RA) as there are record areas to be established on the data track (Figure 7).

HOME ADDRESS 1 (TRACK NUMBER)

Home address 1 (HA1) is the first information on each data track and follows the index point for that track. It is a four-digit number and is the actual physical address (0000-9999) of a track within one access arm area of a module. The track number is pre-recorded (eight-bit unpacked format) in each data track and cannot be written by the user.

HOME ADDRESS 2 (HOME ADDRESS IDENTIFIER)

Home address 2 (HA2), which follows HA1 in each data track, is the home address identifier. It consists of two or more characters, written by the user, which may be numeric, alphabetic, or special characters, in either six-bit or eight-bit unpacked mode. Although the

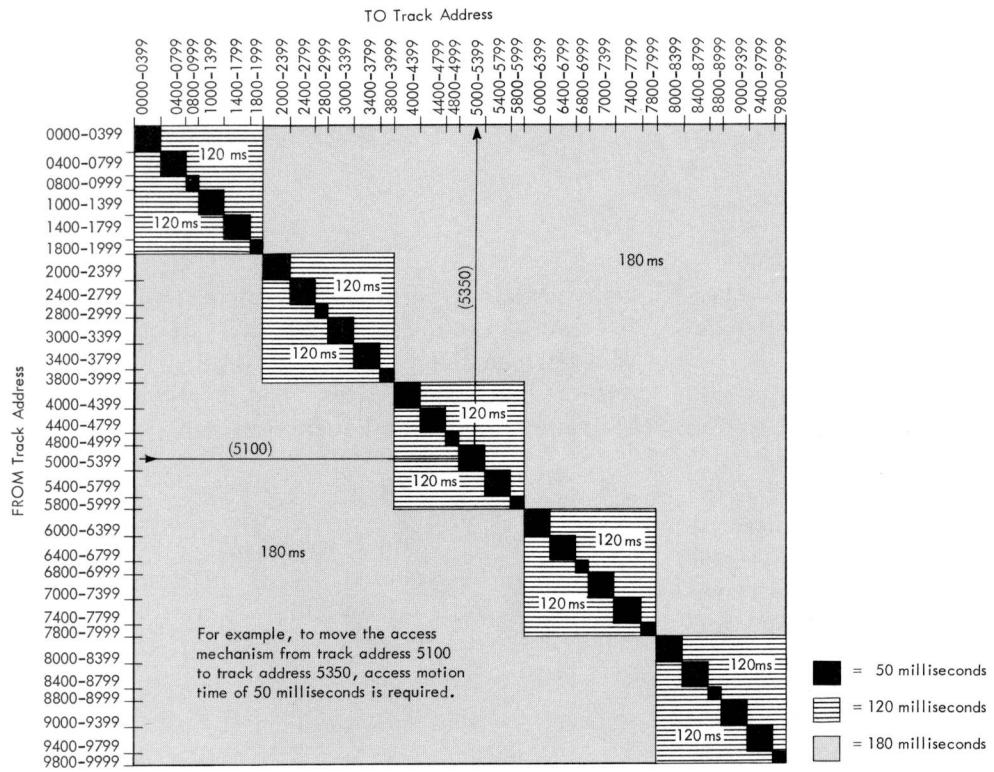


Figure 5. 1301 Disk Storage Access Time

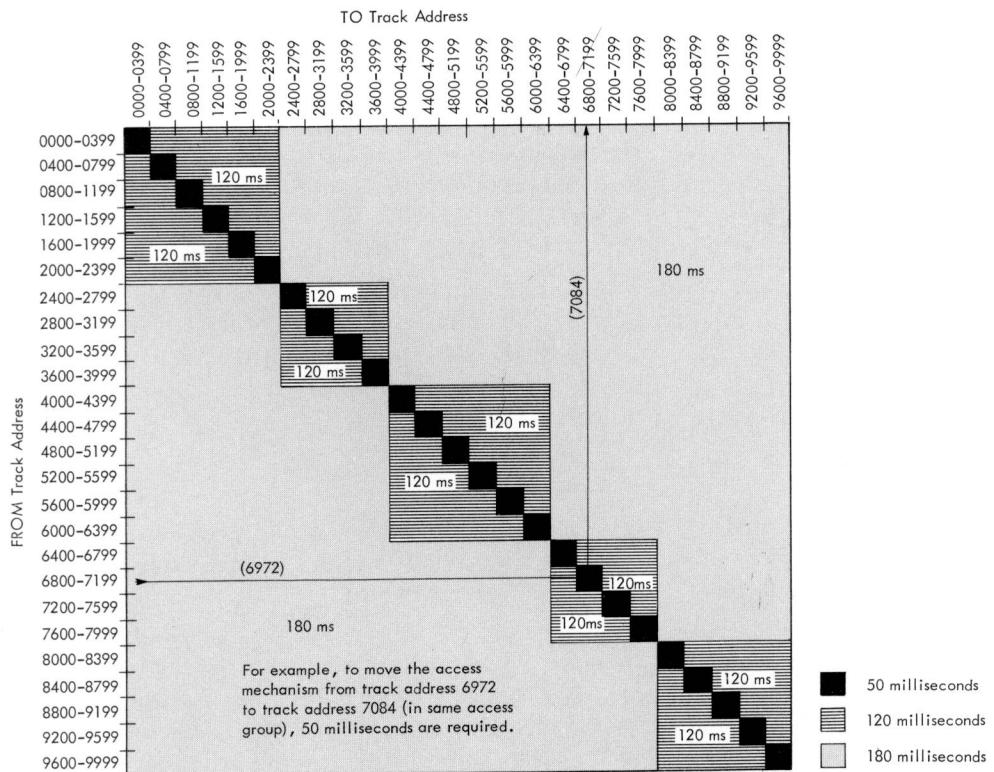


Figure 6. 1302 Disk Storage Access Time

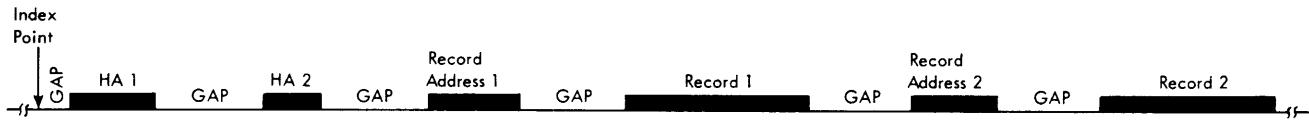


Figure 7. Disk Track Address and Data Arrangement

home address identifier can be greater than two characters long — only the first two characters are verified in machine operations.

Use of more than two **HA2** characters is primarily related to shared disk operations involving IBM 7070, 7074, 7040, 7044, 7090, 7094 and 7094 II systems. Subsequent references to **HA2** will consider, in general, only the first two characters. **HA2** must be written on the data track by the user before actual writing or reading operations for that track. From an addressing or reference viewpoint, the combined **HA1** and **HA2** become the actual address of a data track in a module; **HA2** simply provides a method by which the user is able to further define the address of each data track. Identification of a track in subsequent reading or writing operations must indicate both the prerecorded **HA1** address and the **HA2** address established by the user.

In addition to its use as the home address identifier, the **HA2** address can serve many useful purposes. For example, **HA2**, incorporated as part of the track address, can be used as a coded file protection device. That is, in using this file protection scheme, a **HA1** address without a proper **HA2** address will not allow a data track to be referenced.

RECORD ADDRESS

The data track storage area following the **HA1** and **HA2** addresses is one long continuous area for the storage of data. The organization of this space, the number of records to be stored, the number of characters in each record, and the identification of each record area are determined by the user. The operations necessary to accomplish layout (format) of data must be performed before the data track can be used for reading or writing. See "Format Track."

Each record area established for a data track is preceded by a record address (**RA**) (Figure 7). The record address consists of six or more characters, which may be numeric, alphabetic, or special characters. They are assigned and written by the user to fit any convenient addressing scheme. A record address need not have any relationship to the home address of the track where it is written. When the record address (six characters) is verified, only the numeric portion (four low order bits) of the first four characters is verified. The low-order six bits of the last two characters are

verified. Only six record address characters are verified. Because of the ability of the 1301, Models 1 and 2, and 1302, Models 1 and 2, to store different length records, highly efficient use of disk storage and flexibility of data organization are provided.

DATA RECORDS

Records on a data track can be of any length from a minimum of two characters for the 1301, Models 1 and 2, and nine for the 1302, Models 1 and 2, to the full length of the data track, less necessary character spaces for a home address, record address, and required gaps.

DATA TRACK GAPS

The gaps following information areas on the data track are required for machine control and code checking purposes. As each information area of the disk is being written (**HA1**, **HA2**, record addresses, and records), machine check information is automatically generated and placed in the gap following the area being written. As each of these information areas is read in subsequent operations, new check characters are automatically generated and compared bit for bit with the check characters previously placed in the gap when the information area was written. If they do not compare, an error is indicated.

Note: The index point (Figure 7) is used as a machine reference point on the track; that is, it indicates both the beginning and the end of the track. The index is used by the 7631 in file-control/disk-storage synchronizing functions. The index is not normally used in programming operations.

DATA RECORDING

Information is recorded on a disk track serially by character and serially by bit. A space bit(s) separates characters within a record.

Information to be written on disk is transferred, character by character, from core storage to the 7631. An odd-bit parity check is performed on each character. A space bit is inserted, and the character is written on the disk. During disk reading, information is read from disk, character by character. The space bit is removed, an odd parity is generated, and the character is sent to core storage.

DATA TRACK CAPACITIES

Each data track on the 1301, Models 1 and 2, has a capacity of 2,840 six-bit or 2,205 eight-bit character positions for recording information. On the 1302, Models 1 and 2, the total track capacities are 5,902 six-bit and 4,585 eight-bit character positions. These figures have been adjusted to compensate for the character positions used in the prerecorded home address 1 (HA1) and the accompanying gaps for the home address. To determine the number of character positions available for storing records, the character positions required for HA2, record addresses, and additional required machine gaps must be considered.

The maximum number of data characters that can be recorded on a data track can be calculated:

1301 Models 1 and 2

Six-bit mode: $2,840 - HA2^* - n (RA^{**} + 32) = 2,800$
maximum

Eight-bit mode: $2,205 - HA2^* - n (RA^{**} + 32) = 2,165$
maximum

1302 Models 1 and 2

Six-bit mode: $5,902 - HA2^* - n (RA^{**} + 44) = 5,850$
maximum

Eight-bit mode: $4,585 - HA2^* - n (RA^{**} + 44) = 4,533$
maximum

where: $n = \text{number of records per track}$

*HA2 is minimum of two characters

**RA is minimum of six characters.

Note: Records must be at least two characters long for 1301, Models 1 and 2, and nine characters long for 1302, Models 1 and 2.

Table 1 shows the number of records per track for different record lengths and the number of character positions that can be used, as desired, by the program. To calculate what size record can be placed in the remainder of a track, assuming that the same record address is to be used, subtract 32 for 1301, Models 1 and 2, or 44 for 1302, Models 1 and 2, from the remainder.

Format Track

The advanced characteristics of the 1301, Models 1 and 2, and 1302, Models 1 and 2, permit the user considerable flexibility in establishing how the disk storage space is to be allocated, organized, and addressed.

This flexibility of disk storage use makes possible a wide variety of storage formats to meet the needs of many different applications; it also requires that the user organize the disk storage in some particular for-

NUMBER OF RECORDS/ TRACK	Six-Bit Mode			Eight-Bit Mode		
	1301 - 1, - 2	RECORD SIZE (IN CHARACTERS)	REMAINDER	1302 - 1, - 2	RECORD SIZE (IN CHARACTERS)	REMAINDER
1	2,800	0	5,850	0	2,165	0
2	1,381	0	2,900	0	1,063	1
3	908	0	1,916	2	963	1
4	671	2	1,425	0	512	3
5	529	3	1,130	0	402	3
6	435	0	933	2	329	1
7	367	3	792	6	276	5
8	316	6	685	0	249	7
9	277	3	605	5	205	7
10	245	8	540	0	182	3
11	220	0	486	4	162	3
12	198	6	441	8	145	7
13	180	4	403	11	131	6
14	164	10	371	6	119	5
15	151	3	343	5	108	13
16	139	6	318	12	99	11
17	128	16	297	1	91	10
18	119	12	277	14	84	7
19	111	7	260	10	77	18
20	103	18	245	0	72	3

Table 1. Records per Track

mat before its use as a data storage device. These activities can be likened to the wiring of a control panel for unit record machines, to the housekeeping preparations for a program, or to masking a storage area for future use. For clarity of understanding disk storage, it is important that the operations required for establishing the format track of disk storage should not be confused with the operations related to the use of disk storage.

Before any data can be written on or read from a data track within a cylinder, a format track for that cylinder must be written. The format tracks, one for each cylinder, are located on one of the additional disk surfaces not used for data.

FUNCTION OF THE FORMAT TRACK

The function of the format track is to control the use of the data tracks of a cylinder. Once a format track has been written, it establishes the location, character size, and mode of reading or writing that can take place in the home address area, the record address areas, the record areas, and certain gap areas. Data to be written on or read from each data track of a cylinder must conform to the format established by the format track for that cylinder.

The layout and writing of the format track is under the complete control of the user. Once written, however, the format for a cylinder of tracks remains fixed until the format track is rewritten.

To prevent unintentional changes to the information recorded on the format tracks, each disk module is

provided with a two-position key lock switch. A format track can only be written on when the switch is in a **WRITE** position. The switch is normally placed in a **READ** position.

FORMAT TRACK CONTROL CHARACTERS

The control characters used to write a format track must first be organized in core storage as a record (format control record). The prepare to write format order, followed by a write command, transfers the core storage format control record to the 7631 File Control. It is converted to a special bit configuration, for machine control purposes, and is written on the addressed format track. Since the format track defines, in machine form, the control action previously defined in the core storage format control record, explanation of how the data tracks of a cylinder are defined will be made in terms of the core storage format control record.

Four different characters, **BCD** 1, 2, 3 and 4 are used to compose a format control record in core storage. The **BCD** characters 1 and 2 define data track areas that will be handling data in a six-bit mode. The **BCD** characters 3 and 4 define data track areas that will be handling data in an eight-bit mode. Certain format track areas are for machine control and data checking purposes. These areas must be provided unconditionally in the core storage format control record.

Figure 8 shows a typical core storage layout of a format control record in both the six-bit and eight-bit mode.

1301 Models 1 and 2, Format Track Core Storage Layout													
	Gap	HA1	Gap 2	HA2	X Gap	RA1	Y Gap	Record 1	X Gap	RA n	Y Gap	Record N	Gap
6-Bit	444	333333333	43333333334	1111111	22222222222	11111111111	211111111112	111---111	22222222222	11111111111	211111111112	111---111	2
8-Bit	444	333333333	43333333334	333333	444444444444	333333333	43333333334	333---333	444444444444	3333333333	43333333334	333---333	4
Number of BCD Characters (1,2,3, or 4)	3	9	12	6 Min	12	10 Min	12	6 Min	12	10 Min	12	6 Min	1
Min = Minimum													

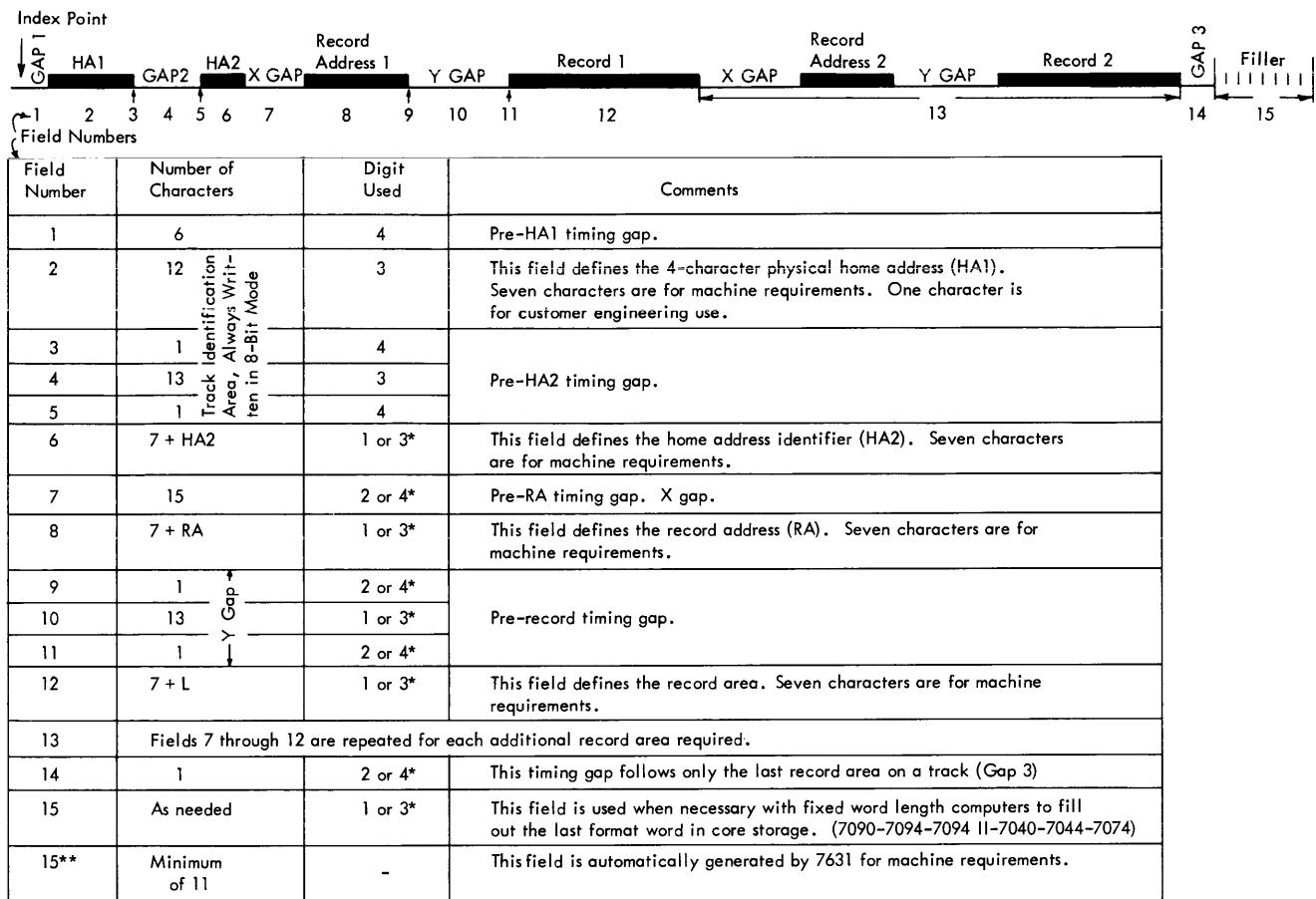
1302 Models 1 and 2, Format Track Core Storage Layout													
	Gap 1	HA1	Gap 2	HA2	X Gap	RA1	Y Gap	Record 1	X Gap	RA n	Y Gap	Record N	Gap
6-Bit	444444	3333333333	433333333334	11111111	222222222222	111111111111	211111111112	111111111112	222222222222	111111111111	211111111112	111111111111	2
8-Bit	444444	3333333333	433333333334	33333333	444444444444	333333333334	433333333334	33333333	444444444444	333333333333	433333333334	333333333334	333333333334
Number of BCD Characters (1,2,3, or 4)	6	12	15	9 Min	15	13 Min	15	9 Min	15	13 Min	15	9 Min	1
Min = Minimum													

Figure 8. Core Storage Format Control Record – n Records

FORMAT TRACK ARRANGEMENT

The core storage format control record is transmitted to the specified format track by appropriate program-

ming. One format track is required for each cylinder of 40 data tracks. Figure 9 shows format track arrangement and associated field number information.



L = Number of characters in record area.

* Ones or twos are used for 6-bit mode, threes or fours are used for 8-bit mode.

** This field is never in core storage; it appears only on the format track.

Figure 9. Format Track Arrangement

IBM 7631 File Control

Systems Requirements

Ten disk modules (five disk storage units) may be attached to a computer through one or two properly adapted IBM 7631 File Controls. Existing file controls with a machine serial number of 12,000 or higher may be field-modified to control the IBM 1302, Models 1 and 2, Disk Storage. The 1301, Models 1 and 2, and 1302 Models 1 and 2, may be intermixed. In 7090, 7094, and 7094 II systems, the IBM 7320 Drum Storage unit(s) can also be attached to the 7631 to operate with the 1301 and 1302 Disk Storage units.

The IBM 7631 File Control is available in five models:

	FOR SINGLE SYSTEM DISK STORAGE USAGE	FOR SHARED DISK STORAGE USAGE
Model 1	1410 7010	
Model 2	7070, 7074 7080 7090, 7094, 7094 II 7040, 7044	
Model 3		7070, 7074 7080, 7090, 7094, 7094 II 7040, 7044 } with 1410 7010
Model 4		7070, 7074 7080, 7090, 7094, 7094 II 7040, 7044 } with 7090, 7094, 7094 II 7040, 7044
Model 5	1410 } 7010 } with 1410 7010	7070, 7074 7080, 7090, 7094, 7094 II 7040, 7044 }

File Control Unit Functions

The 7631 File Control performs a variety of functions in a disk storage processing operation; some of these are:

Decode and Execute Disk Orders transmitted from the computer main storage to the disk storage units by way of data channels.

Assemble and Disassemble Characters transmitted between the computer and disk storage.

Perform Data and Program Checking (parity checking, address verification, invalid operation codes, error detection, etc.) of information received from, or going to the computer.

Provide Monitoring Services and Allied Programmed Interrogation between disk storage and the attached computer, by the use of communication signals to indi-

cate various disk storage processing conditions. Some of these monitored conditions are: disk storage receipt of a transmitted order, successful or unsuccessful execution of a disk operation, and indication of the status of the several disk modules.

COMMUNICATION SIGNALS

Three types of monitoring signals are transmitted from the disk-storage/file-control subsystem back to the computer, and one signal is transmitted from the computer to the file-control/disk-storage subsystem. These signals are:

End: This signal is issued by the 7631 File Control and transmitted to the computer to indicate compliance with an order sent to the disk storage units. The end signal indicates that the order has been received and decoded and that execution has either been started or has been successfully completed.

Unusual End: The 7631 checks for 12 possible error or unusual conditions in disk storage operation. Any of these conditions causes an unusual-end signal to be sent to the computer. Causes of the unusual-end signal are recorded in 7631 File Control. This recorded information (status data) can be transmitted to the computer main storage for stored program interrogation. Status data are retrieved from the 7631 by a data channel sense command, which is similar to a read command except that only ten four-bit characters are transmitted to the computer. Sense data words (up to two) transmit the status data — incorporating both error condition indications and attention indications. If an unusual-end signal is generated by the 7631 and the computer is not programmed to issue a sense command to retrieve the recorded status data, the status data will be lost when the next data channel command is issued.

Attention: This signal is generated by the disk storage subsystem to indicate to the computer that a previously given seek operation has successfully positioned the addressed access mechanism at the specified track location and selected the desired read-write head. The attention signal should be followed by a sense command to determine the specific disk module involved.

Stop: This signal is generated by the computer and is transmitted to the file control to indicate the completion of a CPU operation. On receipt of the stop signal, the 7631 responds to the CPU with either an end or unusual-end signal.

ERROR AND UNUSUAL CONDITIONS

The 12 error and unusual conditions checked by the 7631 and resulting in an unusual-end signal are:

Parity or Character Check: This check indicates the gain or loss of bits during a read or write check operation.

The 7631 is an odd-parity machine. As characters are transferred from the computer, a bit count of each character is performed. If an even number is counted, a check bit, as well as a summary data check bit, is produced and set in to the status data.

The character code check is made by generating three check characters for each address and record as bits are read from the disk surface during a read operation. These newly generated characters are then compared bit-by-bit with those previously generated and recorded in the gap following each address and each record during the write operation. Failure to compare will indicate the occurrence of an error.

Invalid Address Check: If a seek operation is attempted using an invalid address with a read or write command, an invalid address check occurs. This check does not occur during a prepare-to-verify operation.

Response Check: This check indicates that a character was not received by the 7631 within the allotted time. Response check can occur only as a result of a read or write operation.

Data Compare Check: This check can occur only during a write check operation. The condition indicates that a data compare error was detected somewhere during write check. During a write check operation, data are read from a data disk surface and compared bit-by-bit with data transferred from the computer.

Format Check: The format check occurs during either format write or a write check of a format track. It may occur because of an illegal code (other than a BCD 1, 2, 3, or 4), or because the stop signal was not sent to the file control before the index point is sensed.

No Record Found: This indication occurs if the file control fails to locate the track address that was issued to it on a prepare-to-verify order.

Invalid Sequence: The invalid sequence condition can occur during write operation in two ways: it occurs when a write command is received by the file control without a preceding and properly executed prepare to verify or prepare to write format order; or, when a prepare to write check order is preceded by other than a write command. During reading, a prepare to verify is the only legal order that can precede a read command.

Invalid Code: This indication occurs when the file control is given an order that is not defined for the disk file.

Access Inoperative: This indication occurs when the access mechanism fails to respond to a seek order. The access may be mechanically out of order or may not exist.

Access Not Ready: This indication shows that the addressed access is in motion from some prior seek order.

Disk Storage Circuit Check: This check indicates a circuit failure in the disk storage unit.

File Control Circuit Check: This check occurs because of malfunctioning of the 7631 circuitry.

STATUS DATA BITS AND SENSE WORDS

The status data bits and their assignment in the two sense words are as follows:

SENSE WORD	BIT POS.	BCD BITS	STATUS INDICATION	COMMENT
1	1	A	Reserved	Summary Byte
1	3	4	Program Check	Summary Byte
1	4	2	Data Check	Summary Byte
1	5	1	Exceptional Condition	Summary Byte
1	7	A	Invalid Sequence	Program Check
1	9	4	Invalid Code	Program Check
1	10	2	Format Check	Program Check
1	11	1	No Record Found	Program Check
1	13	A	Invalid Address	Program Check
1	15	4	Response Check	Data Check
1	16	2	Data Compare Check	Data Check
1	17	1	Parity or Check Character Code Check	Data Check
1	19	A	Access Inoperative	Exceptional Condition
1	21	4	Access/Module Not Ready	Exceptional Condition
1	22	2	Disk Storage Circuit Check	Exceptional Condition
1	23	1	File Control Circuit Check	Exceptional Condition
1	25	A	Reserved	Data Mode
1	27	4	Six-Bit Mode	Data Mode
1	28	2	Reserved	Data Mode
1	29	1	Reserved	Data Mode
1	31	A	Access 0 - Module 0	Attention
1	33	4	Access 0 - Module 1	Attention
1	34	2	Access 0 - Module 2	Attention
1	35	1	Access 0 - Module 3	Attention
2	1	A	Access 0 - Module 4	Attention
2	3	4	Access 0 - Module 5	Attention
2	4	2	Access 0 - Module 6	Attention
2	5	1	Access 0 - Module 7	Attention
2	7	A	Access 0 - Module 8	Attention
2	9	4	Access 0 - Module 9	Attention
2	10	2	Access 1 - Module 0	Attention
2	11	1	Access 1 - Module 1	Attention
2	13	A	Access 1 - Module 2	Attention
2	15	4	Access 1 - Module 3	Attention
2	16	2	Access 1 - Module 4	Attention
2	17	1	Access 1 - Module 5	Attention
2	19	A	Access 1 - Module 6	Attention
2	21	4	Access 1 - Module 7	Attention
2	22	2	Access 1 - Module 8	Attention
2	23	1	Access 1 - Module 9	Attention

Switches and Lights

The control panel on the right front cover of the 7631 is intended primarily for maintenance purposes. In addition to the exposed section, the control panel has a covered section intended for customer engineering use only. On the exposed section there are 122 indicator lights that reflect the status of the data and controls within the 7631. The customer engineering section contains 35 switches for simulation of data and machine control. Operator switches are available in a switch and light assembly above the indicator section of the control panel.

7631 SWITCHES AND LIGHTS

Power-On Switch: This switch sequentially turns on the AC and DC power to the 7631 and attached 1301 and 1302 units. Depression of this switch, with DC power off, will turn on DC power.

Power-On Light: This light turns on when AC power is on in the 7631, 1301 and 1302 units.

DC-On Light: This light turns on when DC power is developed in the 7631.

DC-Off Switch: This switch turns off DC power in the 7631, 1301 and 1302 units.

Power-Off Switch: This switch removes DC and AC power from the 7631 and all connected 1301 and 1302 units.

HAO Switch: This switch must be on to execute the home address operation.

Write Inhibit Switch: This switch, when on, allows the customer engineer to perform a write sequence of operations without the actual writing, thus not disturbing the customer's data.

Write Inhibit Light: This light is on when the write inhibit switch is on.

Test Mode Light: This light indicates that the 7631 and the attached disk storage units are not available for normal customer use.

Thermal Light: This light automatically turns on if the internal machine temperature exceeds 115 degrees Fahrenheit; DC power is automatically turned off. DC power can be restored with the power-on-switch after the machine temperature returns to normal operating limits.

Fuse Light: This light turns on and DC power is removed if any auxiliary AC or DC circuit breakers trip.

1301-1 AND -2 — 1302-1 AND -2 SWITCH

Write Format Track Switch: This key-operated lock switch has a read (RD) and a write (WR) position. To position the switch, a key must be inserted and turned. The switch must be set to the WR position to perform a write format track operation. The position of this switch has no effect on any operation except write format. Each disk module has its individual write format track switch.

Operations performed by the 7631 File Control, 1301 Models 1 and 2, and 1302 Models 1 and 2 Disk Storage, and 7909 Data Channel are based on the execution of instructions, commands, and orders.

Figure 10 shows the span of control and resulting activities of the execution of instructions, commands and orders in a 7090, 7094, and 7094 II – disk storage operation.

Instructions

Instructions are system-coded information that is decoded and executed by the central processing unit to perform specific operations, such as the selection of data channels, resetting and loading of data channels, start data channels, and so on.

Commands

Commands are systems-coded one-word “instructions” to the data channel. The commands are decoded and executed by the 7909 Data Channel to perform a specific operation in the data channel or between the data channel and the 7631 File Control.

Four basic commands are executed by the data channel and cause activity in the 7631. They are: read, write, sense, and control commands.

Read and write commands set up control circuitry in the 7909 to permit information transmission between the disk storage and the main computer system through the 7631.

Sense commands cause transmission of status data from the 7631 to the main computer system to indicate status conditions existing in the 7631 and the (disk) storage.

The control command is used to transmit orders to the 7631 and to supply the file control with one or more order words that contain operation and address information.

Reading and writing of disk storage data may be handled in five modes: home address operations, single address operations, track operations, track without addresses operation, and cylinder operations.

Each mode causes a comparison activity, followed by a transfer of information activity (providing the comparison has been successful). The transfer activity effects transmission of data to or from the disk, according to the mode of data handling involved. The comparison is accomplished by a bit-by-bit verification of the address incorporated in the order, as received from

core storage, and compared to the actual address selection of the disk storage unit. If the comparison is successful, data are transferred to or from specific areas of the disk storage unit (as determined by the mode of operation involved). If the comparison is unsuccessful, a no record found indication and an unusual-end signal are issued to the system by the 7631.

Operating Modes

Home Address Operation: The physical home address (**HA1**) is compared with the **HA1** in the order, followed by the transfer of the **HA2** plus all additional addresses and records on a given track.

Single Record Operation: The record address selected on the disk storage is compared with the record address in the order, followed by the transfer of the associated single record only.

Track Operation: The entire home address (**HA1** and **HA2**) of the selected home address on the disk storage is compared with the home address in the order, followed by the transfer of all record addresses and records on a single track.

Track Without Addresses: The entire home address of the selected track on the disk storage is compared with the home address in the order, followed by the transfer of all data records contained in the remainder of the track.

Cylinder Operation (Optional Feature): The entire selected home address of a particular track in a cylinder is compared with the entire home address in the order, followed by the transfer of all records contained in the particular track and all succeeding tracks of higher address within that cylinder.

Orders

Orders, in the form of characters (Figure 11), are decoded and executed by the 7631 and specify what non-data operations will be performed and where they will be performed in the disk storage. The orders are transmitted from core storage as one or two core storage words, depending on the number of characters required in each order. Some orders require only two characters; other orders require a full complement of ten characters.

Operation Code: This is a two-digit code, expressed as a **BCD** numeric character. The operation code is all that is required for such operations as disk release, disk eight-bit mode, and disk six-bit mode.

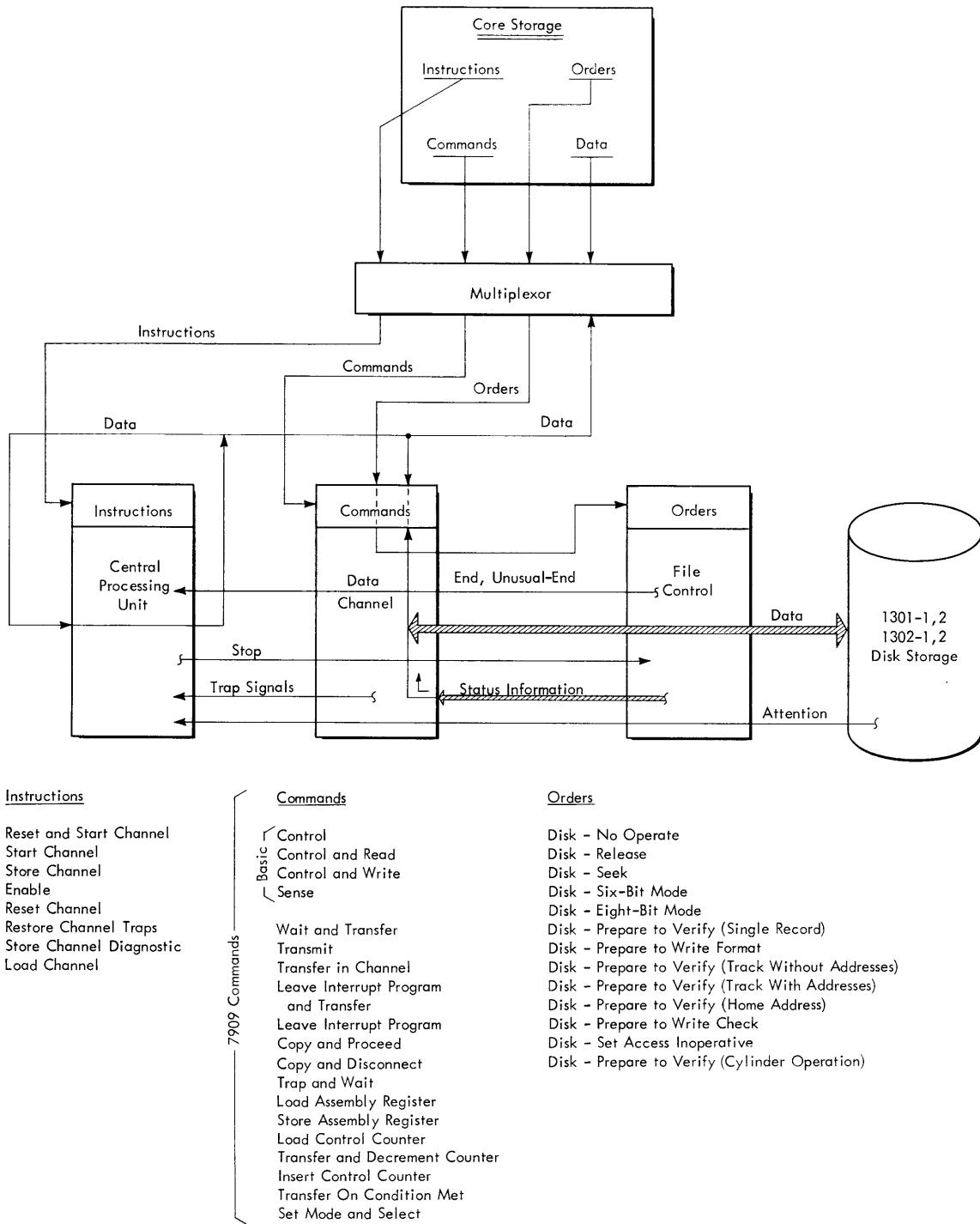


Figure 10. Span of Control – Instructions, Commands and Orders

Access and Module Number: These two positions of the order are always numeric. The access in the 1301-1 and -2 is always referred to as access 0. The two access mechanisms of the 1302-1 and -2 are referred to as access 0 or access 1. The module number is determined by the cabling of the 7631.

Record/Home Address: The use of these character positions depends on the operation to be performed. In operations in which the address is not required, it is not necessary to use these positions. For operation codes that require addressing of the home address, these positions must contain the track/head number

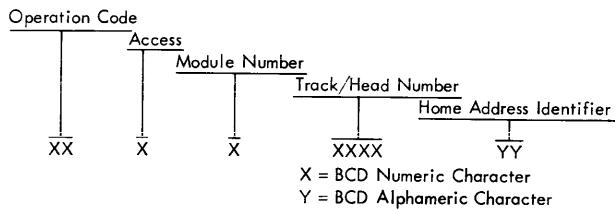


Figure 11. Simplified Order Format

and record number. For operations affecting only a single record, these positions should contain the record address of the desired record. In a checking operation, these positions contain the home address or the record address used in the write operation to be checked.

File Control Orders

The 7631 will decode and execute up to 13 orders transmitted from core storage by the control command. The 7631 decodes the transmitted order, accepts address information, performs the designated function, and then transmits an end or unusual-end signal to the data channel. At the completion of the seek operation, the 7631 sends an attention signal to the data channel.

The 7631 File Control orders are shown in Figure 12 with mnemonics, operation name, byte configuration, and numeric code.

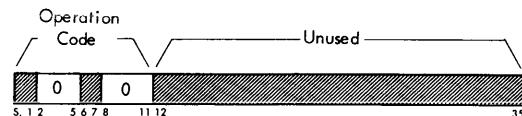
Mnemonic	Operation	Byte B1 8 4 2 1	Byte B2 8 4 2 1	Numeric Code
DNOP	No Operation	1 0 1 0	1 0 1 0	00
DREL	Release	1 0 1 0	0 1 0 0	04
DEBM	Eight-Bit Mode	1 0 1 0	1 0 0 0	08
DSBM	Six-Bit Mode	1 0 1 0	1 0 0 1	09
DSEK	Seek	1 0 0 0	1 0 1 0	80
DVSR	Prepare to Verify (Single Record)	1 0 0 0	0 0 1 0	82
DWRF	Prepare to Write Format	1 0 0 0	0 0 1 1	83
DVTN	Prepare to Verify (Track Without Address)	1 0 0 0	0 1 0 0	84
DVCY	Prepare to Verify (Cylinder Mode)*	1 0 0 0	0 1 0 1	85
DWRC	Prepare to Write Check	1 0 0 0	0 1 1 0	86
DSAI	Set Access Inoperative	1 0 0 0	0 1 1 1	87
DVTA	Prepare to Verify (Track with Address)	1 0 0 0	1 0 0 0	88
DVHA	Prepare to Verify (Home Address)	1 0 0 0	1 0 0 1	89

* Optional Feature

Figure 12. Disk Storage Orders

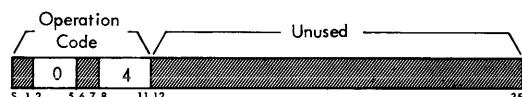
Some orders require one word 7090, 7094, or 7094 II in core storage, while others require two consecutive locations in core storage.

No Operation (DNOP-00)



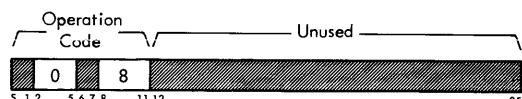
Disk Operation: This order requires only a two-digit operation code. The order is accepted by the 7631 as a programming modification convenience only. No function is performed by the 7631 for this order.

Release (DREL-04)



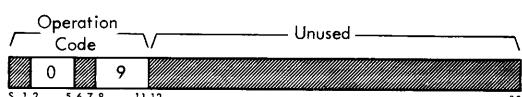
Disk Operation: This order requires only a two-digit operation code. The order has meaning only for shared system operation. Whenever either system selects and gains control of the 7631, it remains in control of that system until the release order is issued to permit the file control to be available for either system.

Eight-Bit Mode (DEBM-08)



Disk Operation: This order requires only a two-digit operation code. The order conditions the 7631 to operate in the eight-bit mode. This mode of operation is required when the shared system is operating in the eight-bit mode. The 7090, 7094 and 7094 II systems do not use eight-bit mode except in shared systems operation.

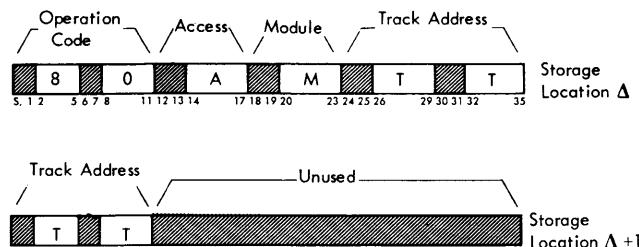
Six-Bit Mode (DSBM-09)



Disk Operation: This order requires the two-digit operation code only. The DSBM order conditions the

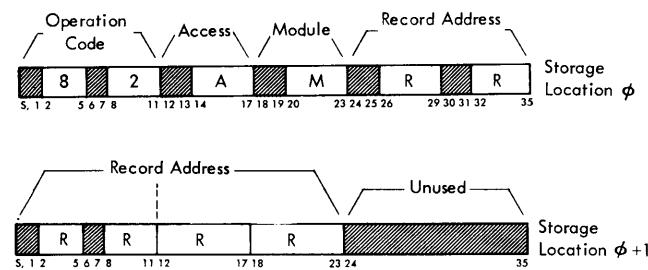
file control to operate in the six-bit mode. The 7090/7094/7094 II systems normally process data in six-bit mode.

Seek (DSEK-80)



Disk Operation: The order for this operation causes the specified access mechanism of the addressed module to locate itself at the proper cylinder and to select the desired head. When the order has been received by the file control, it gives an end signal and allows the computer to continue with its own routine while disk storage executes the seek operation. A seek may be simultaneously directed to other access mechanisms on the same disk storage module or other modules attached to the same file control. An unusual end signal results if a seek is given to an access mechanism in motion or if the access mechanism is inoperative.

Prepare to Verify, Single Record (DVSR-82)



Disk Operation: The order for this operation conditions the 7631 for a single-record type of operation and to:

1. Select the desired module and access mechanism.
2. Specify the address to be verified.
3. Prepare to transmit data from or to the addressed record in response to a subsequent single record read or write command.

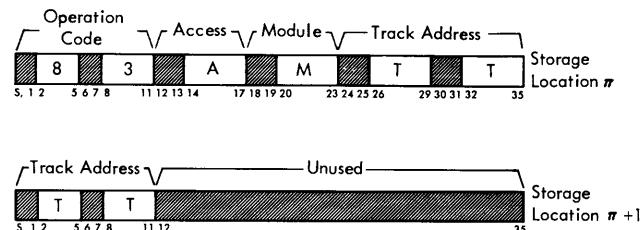
The order sent to the 7631 is used with the read or write command. Access and module number specify the unit to be selected. Since the access mechanism is already located and held in the track position and the desired head is selected by the previous seek

operation, the remainder of the order is used only for verification.

The file control (in single-record mode) compares each record address, as it comes under the read head, against the address furnished by the order until the desired address is found.

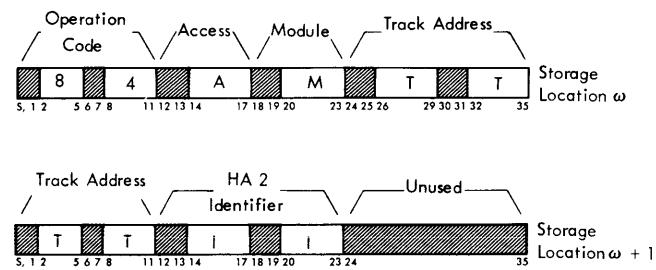
Information can be read from or written into record areas only as defined by format tracks. Reading or writing continues until either a stop signal is issued by the computer or the 7631 recognizes the end of record, depending on whether a read or write command is being executed.

Prepare to Write, Format (DWRF-83)



Disk Operation: This order conditions the 7631 to write a format track for the cylinder specified by the address portion of the order (the last two positions of this order are insignificant). To address a format track, the format two-position key-lock switch must be in the write position; the track address must be one of the track addresses of the cylinder associated with the format track. To write a format track, this order must precede the write command.

Prepare to Verify, Track Without Addresses (DVTN-84)



Disk Operation: This order, followed by a read or write command, permits reading or writing only the records on a particular track; all addresses are skipped over. The address portion of this order must specify the home address.

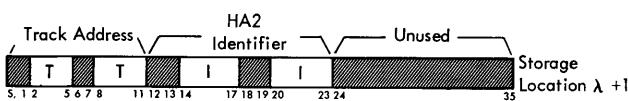
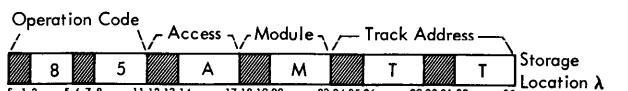
This order instructs the 7631 to:

1. Select the desired module.
2. Supply the home address to be verified.

3. Receive or transmit only the records in response to a subsequent read or write command.

Reading or writing begins at the first record following the home address, and continues through the records, skipping over addresses until the computer signals stop or the 7631 recognizes the end of the data areas. Nonverification of the home address results in an unusual-end signal, with no transmission of data to or from disk storage.

Prepare to Verify, Cylinder Operation (DVCY-85)

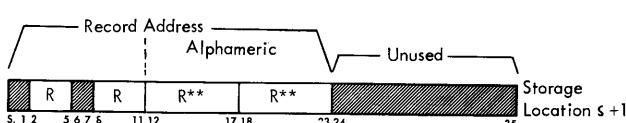
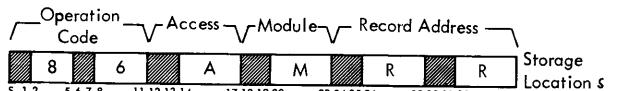


Disk Operation (Optional Feature): This optional feature permits reading or writing of data (skipping over addresses), beginning at the first record after the home addresses of the addressed track and continuing through successive record locations and the tracks of the cylinder until either the end of cylinder is reached or the computer signals a stop. This order is always followed by a read or write command.

The following functions are performed in the cylinder operation mode:

1. Select desired module and access mechanism.
2. Specify desired home address to be verified.
3. Transmit data after the subsequent read or write command has been given.

Prepare to Write Check (DWRC-86)



** Must be the HA2 Identifier (I) used in the write operation to be checked.

Disk Operation: This order is used with a write command to check any record, track, or cylinder of tracks of information. This order performs a bit-for-bit comparison, comparing the information recorded on the disk with the same information stored in core storage

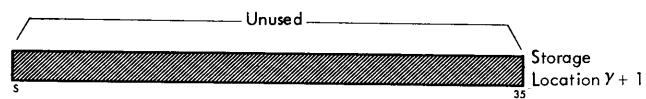
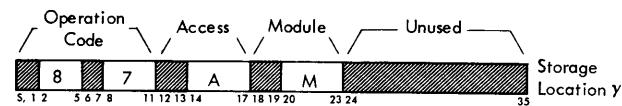
of the computer. If data agree, the order terminates with an end signal; if data disagree, the order terminates with an unusual end signal. The sequence of commands and orders to write and check recorded data is:

Seek	-----
Prepare to Verify (Single, Track, Cylinder)	XXXXXXX*
Write	-----
Prepare to Write Check	XXXXXXX*
Write	-----

* Must be same address

The use of the write check operation is optional, depending on the application.

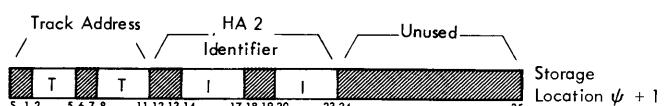
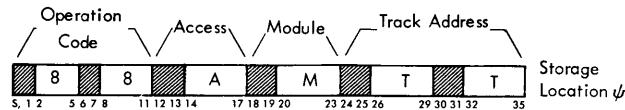
Set Access Inoperative (DSAI-87)



Disk Operation: This file control order causes the 7631 to disconnect the addressed access unit from the file control. (It permits the programmed disconnection of a faulty access unit from the system.) Any subsequent command to this access will result in an unusual-end.

Note: Reactivation of the inoperative access unit is accomplished manually by the customer engineer after the fault has been corrected.

Prepare to Verify, Track with Addresses (DVTA-88)



Disk Operation: This order, followed by a read or write command, permits reading or writing a full track of information, including record addresses and records. It makes use of the home address that defines the track address.

This order instructs the file control to:

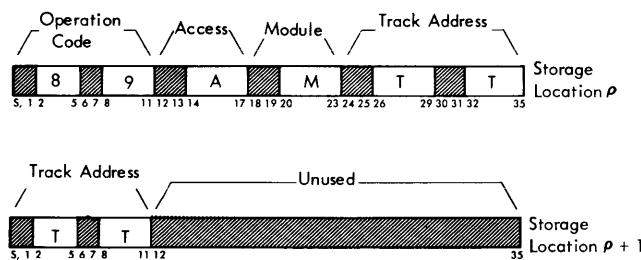
1. Select the desired module and access mechanism.
2. Supply the home address to be verified.

3. Condition the 7631 to operate on a full-track basis and receive and transmit both record addresses and record areas in response to a subsequent read or write command.

The order is normally used whenever changes are to be made to record addresses and insertions or deletions are to be made on a track that contains randomly distributed records.

The execution of this order is similar to that performed by the prepare to verify (cylinder operation) in that only the home address is verified. If verification is successful, reading or writing begins at the following record address and continues through the records and the record address until the computer signals a stop or the 7631 recognizes the end of the data areas. Non-verification of the home address results in an unusual-end signal with no transmission of data to or from the disk storage.

Prepare to Verify, Home Address (DVHA-89)



Disk Operation: This order prepares the 7631 to read or write an entire track of data and addresses including the home address identifier (HA2). The home address must be supplied for subsequent verification. For execution of this order, the home address switch must be on. (The switch is on the 7631 File Control.)

This operation is terminated by a stop signal from the computer or when the 7631 recognizes the index point.

Write Operations

A disk write operation is a processing activity in which information from the computer is transmitted and recorded on a disk surface. The information may be written on a track as data or on a format disk surface for format control. Data can be transmitted and written in five operating modes:

- Write Home Address
- Write Track with Addresses
- Write Track without Addresses
- Write Single Record
- Write Cylinder (Optional Feature-r-w Cylinder)

All written data can be verified for accuracy and fidelity of recording by a write check operation.

A write command must always be preceded by a prepare to write check, prepare to write format, or a prepare to verify order. A write command not preceded by one of these orders is terminated with an unusual-end signal with no transmission of data to the file control. (A no operation order can be inserted between the prepare to... and the write command.)

Write Format Track

To write a format track, three conditions must be met:

1. The format switch must be in the Write position; otherwise, no writing of the format track will take place.
2. A prepare to write format order with a track address of one of the tracks must be received and normally terminated by the 7631.
3. The prepare to write format order must be followed by a write command specifying a core storage location that contains the field of BCD characters used to write a format track.

Write Home Address

The conditions necessary for this operation are that the home address switch on the 7631 is on, a prepare to verify (home address) operation order is issued to the file control, and the write command immediately follows. The file control compares the physical address portion of the home address on the track and begins the write operation at the beginning of the HA2 area. The first characters must be the home address identifier of the particular track. The home address identifier must be a minimum of two characters. If desired, this area may be extended to six characters to match the word length of the 7090, 7094 and 7094 II systems. The number of characters requested by the 7631 for the HA identifier is determined by the number of BCD 1's previously written on the format track. All characters of the HA identifier after the second are non-significant and are not a part of address compare operations.

This operation continues, with the file control detecting the gap between HA2 and the first record address. On detection of the gap, the file control writes the three-digit check character. The operation continues writing record addresses and records to the end of the track.

If a stop signal occurs before the end of the track is sensed, data transmission stops but the file control continues writing blanks to the end of the track.

Write Track with Addresses

Conditions necessary for this operation are a prepare to verify (track with addresses) order, followed by a write command. Under control of the prepare to verify

(track) order, the file control searches the data track for a home address and compares this address bit for bit against the address previously issued with the prepare to verify (track) order. If the home address fails to compare, the file control issues an immediate unusual end and indicates in its status word a no-record-found bit. On a successful home address compare, the file control transfers the record address and proceeds in the usual manner. The file control continues filling the record area with data (both records and addresses) from the computer. The file control also supplies the check characters to be written at the end of each area. When the last check character area is reached, a normal end will be issued to the computer if no error conditions have been detected. Otherwise, unusual-end results. If the computer signals a stop in the middle of a record, data transmission stops, but the file control writes blanks to the end of the record area in which it is operating, then writes the check characters, and signals normal end.

Write Single Record

Conditions necessary for this operation are that a prepare to verify (single record operation) order is issued to the file control, followed by a write command. The record address area is recognized in the file control by sensing the end of a long gap in the format. On finding a record address area, the file control reads off the address contained in the area and compares it bit by bit with the address previously supplied to the 7631 during prepare to verify (single record). If the address does not compare, the file control continues searching succeeding address areas and comparing the address contained in each. If the file control passes the index point twice without comparing the address, it registers the no-record-found status bit and issues an unusual end to the computer without transmission of data. On an address compare true, the file control causes the disk to write over the record immediately following the compared address. Data are furnished by the system. The file control automatically transmits the code check characters following the end of the record area as defined by the format track.

If a stop signal is received at some point in the record area, the file control continues to write the record, with blanks, until the end of the formatted area is reached. After the check characters are recorded, a normal end is issued to the system unless a data check has occurred, in which case unusual-end would result.

Write Track Without Addresses

The conditions necessary for this operation are that a prepare to verify (track without addresses) order is followed by a write command. The address received

with the prepare to verify (track without addresses) order is compared with the home address transmitted from the disk. If the home address fails to compare, the no-record-found bit is registered and unusual-end is issued to the system. If the address compares true, the file control skips the first address area into the record area and writes the record. The file control continues skipping addresses and writing the records until the end of the last record on the track is sensed. A normal end is issued to the system if no error conditions occur during data transfer. In case of a parity error, the operation will be terminated at the end of the record in which the error was detected and unusual-end is issued.

If the computer signals a stop in a record, data transmission stops, but the file control continues writing blanks to the end of the record area in which it is operating, then writes the check characters and signals normal end.

Read or Write – Cylinder

Operation in the cylinder mode is an optional feature of the 7631. A cylinder mode read or write is set up by having the computer send a prepare to verify (cylinder operation) order to the file control. The address issued with the order is the home address of the track on which the operation is to start. The home address is compared bit by bit in the 7631 after the read or write is received.

On compare equal, the data transfer operation begins with all records on the addressed track being read or written and with the record addresses ignored in the same manner as a track-without-addresses operation. Rather than causing an end signal when the last record of the track has been processed, the 7631 sends a new head address to the disk and reading or writing continues. The head address sent to the disk is one address higher than the previous head address. By indexing one head address on each disk revolution, the 7631 continues reading or writing until the entire cylinder of information has been processed. The end signal is generated in the 7631 when the highest order head of the cylinder has been operated on.

If the computer signals a stop in a record, data transmission stops but, if reading, the file control continues to the end of record, and then compares check characters; if writing, the file control writes blanks to the end of the record in which it is operating, then writes the check characters and signals normal end.

No wraparound feature is included in cylinder operation to cause operation to begin again at the low-order head after the high-order head has completed its reading or writing.

Write Check

Each write operation has an associated write check operation, the use of which is optional and under program control. The operation requires the following sequences of orders and commands:

Prepare to Verify . . .	XXXXXXX
Write	-----
Prepare to Write Check	XXXXXXX
Write	-----

The 7631 compares the data recorded in the addressed record, bit by bit, with the write data from the system, at the same time generating check characters that will be compared with those previously generated and recorded on the track. The end of this operation is the same as a true write operation. A compare error during a write check sets the data compare check bit in the status data.

During a write check operation on a format track, the format gap detector circuits in the 7631 are checked to determine if they are within their specified tolerance. A file control circuit check is noted if the circuits do not meet specifications.

On reception of a stop signal, the 7631 continues comparing data already received, then continues until the end of the record area and issues a normal end signal.

Read Operations

A disk read operation is a processing activity in which data recorded on a disk surface are retrieved and transmitted to the computer. Data may be read and transmitted to the computer in five operating modes:

- Read Home Address
- Read Track with Addresses
- Read Track Without Addresses
- Read Single Record
- Read Cylinder (Optional Feature-R-w Cylinder)

Read Home Address

This operation requires that a prepare to verify (home address) is sent to the 7631 and that a read command follows. The most useful application of this operation is to recover tracks of information in a file dump operation. The 7631 compares the physical address portion of the home address and begins reading with the home address identifier. All address and record data of the track are read. The termination of this operation occurs when the 7631 senses the index point. At that time either normal end or unusual end is issued, depending on the state of the data check. The computer may terminate the operation earlier by issuing a stop. On receipt of the stop, the 7631 terminates data transmission and internally completes reading the record on which it was operating at the time of the stop. At the end of the particular record, the 7631 sends either

normal end or unusual-end, depending on the state of data check.

Read Track with Addresses

Conditions necessary for this operation are that a prepare to verify (track) order is issued to the 7631, followed by a read command. The file control begins the operation by comparing the home address that accompanied the prepare to verify (track) order against the recorded home address on the selected track. A failure to compare causes a no-record-found signal to be set in the status data and causes an unusual-end to be issued to the system. A successful compare permits the 7631 to begin reading at the first record address area. The record address is read out in its entirety and sent to the system, followed by the record, and then the next address and record, and so on. The operation terminates when the 7631 senses that it has completed comparing the check characters of the last record of a track. At that time, a normal end or unusual-end is issued, depending on the state of data check. A stop signal before the logical end of this operation causes the 7631 to stop data transmission and signal a normal end at the end of the record it is operating on at the time of the stop signal.

Read Single Record

This operation requires completion of a prepare to verify (single record) order and read command. As with write (single record) operation, the read (single record) operation has no predetermined starting point on the disk, that is, when the instruction is received by the 7631, it immediately begins searching for a record address. On finding one, the 7631 does a bit-by-bit comparison. A failure to compare causes the control to continue searching on the next record address. No record found is registered if the 7631 passes the index point twice in its search for a particular record. On obtaining an address compare true, the 7631 causes the record immediately following that address to be read and the data to be sent to the system. The 7631 verifies the legality of the check characters following the end of the record and sends the normal end or unusual-end at that time. A stop signal before the logical end of this operation causes the 7631 to stop data transmission and to signal a normal end at the end of the record.

Read Track Without Addresses

This operation requires that a prepare to verify (track) and a read command, in that sequence, be executed. The 7631 waits for the home address area before beginning to compare the address supplied with the prepare to verify order against the recorded home ad-

dress. A compare failure causes the 7631 to register no-record-found in the status word. If the address compares successfully, 7631 carries out the read-track operation by skipping over the first record address and reading the first record. The operation continues with addresses ignored by the 7631 and only record data

being sent to the system. The operation ends when the 7631 finishes the last record of the track. At that time the appropriate end signal is issued. An early end may occur because of a system stop signal. In that case, the 7631 finishes the record on which it is operating and issues a normal end or unusual-end, as the case may be.

Error Recovery Procedures

The following procedures form the basis of the error recovery routines used in IBM Programming Systems applied to IBM 1301 and 1302 Disk Storage operation. For efficient utilization of IBM 7090, 7094, 7094 II Data Processing Systems, the use of these error recovery procedures is recommended in writing routines involving the 1301, Models 1 and 2, and 1302, Models 1 and 2.

Figure 13 shows the 7631-1301/1302, 7320 error conditions that can occur in 7090, 7094, and 7094 II Data Processing Systems operation and specifies the *minimum* action recommended upon the encounter of the error conditions. All data check error conditions should be examined and handled before correcting program check and exceptional condition error conditions.

Action 1

1. Repeat the original sequence (that is, prepare to verify order and subsequent read or write command) once.
2. If the error condition still occurs, print message type 1 (see below).

Action 2 (For Combined 1301-1302/7320 or 1301-1302 Only Error Recovery Routines)

1. Repeat the original sequence (that is, prepare to verify order and subsequent read or write command) four times.
2. After the fifth error indication, issue a DSEK order (using any of addresses 9 @ 00 to 9 @ 39).

Note: The @ is a convenient method of addressing the customer engineering (CE) track, which is used in access arm recalibration on the Disk Storage.

The seek order, addressed to module 2 and track 39, would appear (in BCD) as shown in Figure 14. The binary representation shows how the order would appear in the two required locations of core storage.

1301-1302 ACTIVITY

1. When a 1301-1302 is addressed, this DSEK (9 @ 00 to 9 @ 39) will cause the access mechanism to be recalibrated by going to the CE track.
2. Upon recalibration, issue a DSEK to any valid address. (This positions the access mechanism to cylinder 0.)

Sense Bit Assignment BCD 7090/94/94 II Bit Bit Pos	Status Condition	Comment	When Encountered During a Read Operation 1301-1302-7320	When Encountered During a Write or Write Check Operation 1301-1302-7320	When Encountered During a Control Operation 1301-1302-7320
A 1 4 3 2 4 1 5	Reserved Program Check Data Check Exceptional Condition	Summary Byte			
A 7 4 9 2 10 1 11	Invalid Sequence Invalid Code Format Check No Record Found	Program Check Program Check Program Check Program Check	Action 1 Not Applicable Not Applicable Action 2.	Action 1 Not Applicable Action 1 Action 2	Not Applicable Action 1 Not Applicable Not Applicable
A 13 4 15 2 16 1 17	Invalid Address Response Check Data Compare Check Parity or Check Char Code Check	Program Check Data Check Data Check Data Check	Action 4 Action 1 Not Applicable Action 3	Action 4 Action 1 Action 3 Action 3	Not Applicable for 1301-1302; Action 4, 7320 Not Applicable Not Applicable Action 1
A 19 4 21 2 22 1 23	Access Inoperative Access (Module) Not Ready 1301-1302-7320 Circuit Check 7631 Circuit Check	Exceptional Cond Exceptional Cond Exceptional Cond Exceptional Cond	Action 1 (Not Applicable, 7320) Action 1 Action 1 Action 1	Action 1 (Not Applicable, 7320) Action 1 Action 1 Action 1	Action 1 (Not Applicable, 7320) Action 1 Action 1 Not Applicable

Figure 13. Error Conditions and Actions Required – 7631, 1301-1302, 7320

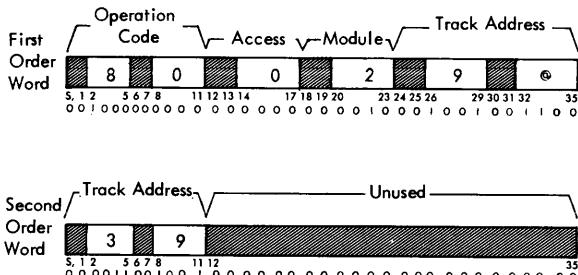


Figure 14. DSEK Order

3. Issue DSEK to the original error-producing address.
4. Repeat the prepare to verify order and read-write command sequence four times.
5. After the ninth error condition occurs, print message type 1.

7320 ACTIVITY

1. If a 7320 is addressed, the DSEK (9 @ 00 to 9 @ 39) will result in an unusual-end (Invalid Address Indication).
2. Issue DSEK to the original error condition producing address.
3. Repeat the prepare to verify order and read-write command sequence four times.
4. After the ninth occurrence of the error condition, print message type 1.

Action 2 (For 7320 Only Error Recovery Routine)

1. Repeat the original sequence (prepare to verify order and read-write command) four times.
 - a. Issue DSEK to the original error condition producing address.
 - b. Repeat the prepare to verify order and read-write command sequence four times.
 - c. After the ninth occurrence of the error condition, print message type 1.

Action 3

1. Repeat the original sequence (prepare to verify order, read-write command) four times. (For write check, the sequence is: prepare to verify, write, prepare to verify, write check.)
2. After the fifth occurrence of this error condition, print message type 1.

Action 4

1. Issue a DSEK order to any valid address.
2. Reissue the original DSEK together with the prepare to verify order and read-write command one time.
3. If the error condition continues, print message type 1.

Message Type 1

Message type 1 identifies an uncorrectable error and is used as a diagnostic aid. Further use and procedure are determined by the application involved.

MESSAGE TYPE 1 FORMAT

Minimum: Items 1 to 3, inclusive.

Recommended (If Core Storage Permits): Items 1 to 7, inclusive.

Maximum: Items 1 to 9.

1. Type of error: read, write, write check, or control.
2. Unit involved: access number, module number, track number.
3. File control status word: bytes 0 to 4 inclusive. An examination of byte 0 will reveal any multiple error conditions.
4. Channel designation and final status or control word for the channel at the time of the error.
5. File control status word: bytes 5 to 9, inclusive.
6. Nature of data: Packed or unpacked (7090-7094-7094 II does not operate in packed mode).
7. Preceding control orders.
8. Previous unit involved: access number, module number, track number, FROM address (the preceding address sought on the module in error).
9. Current unit involved: access number, module number, track number, TO address (the address to which the access was going, or which it had reached, at error time).

Message Type 2

This message provides statistical print-out at the end of a program segment or run, or at some convenient time.

MESSAGE TYPE 2 FORMAT

1. Access number, module number.
2. Number of entries into error routine.
3. Number of type 1 messages printed.

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